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Diseases of Alfalfa in Nevada and Their
Influence on Choice of Varieties



By
O. F. SMITH



Alfalfa Varieties Differ in Resistance to Bacterial Wilt. Center Row is a Susceptible Variety (Grimm) Which Has Been Killed by Wilt, Whereas, the Rows on Either Side are Wilt-Resistant Progenies.

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DISEASES OF ALFALFA IN NEVADA AND THEIR INFLUENCE ON CHOICE OF VARIETIES¹

By O. F. SMITH²

Alfalfa is one of the most widely grown and important crops in Nevada. In recent years alfalfa acreage has decreased to an area in 1947 of approximately 108,000 acres (Figure 1). It is at present grown on 22% of the total cropland and 48% of the cultivated land in the State (Figure 2). In harvested acreage alfalfa is exceeded only by

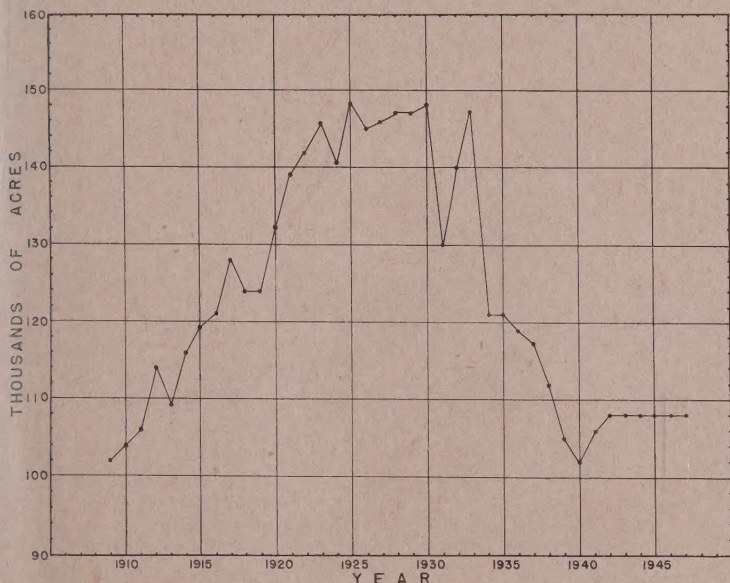


FIGURE 1. Annual Acreage of Alfalfa in Nevada, 1909 to 1947. Data from 1909 to 1923, inclusive, are unofficial estimates based on official U. S. Department of Agriculture estimates of all tame hay acreage. Data from 1924 to 1947 are official U. S. Department of Agriculture estimates supplied by the Bureau of Agricultural Economics.

wild hay. Its most important role is that of furnishing a high quality feed for livestock. Alfalfa is the highest yielding of the commonly grown hay crops, is high in protein and minerals, and is a good source of Vitamin A.

¹Cooperative investigations between the Nevada Agricultural Experiment Station and the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

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In the early days of alfalfa growing in Nevada high production of good quality hay was maintained after seeding for fifteen to twenty years and little thought was given to the problem of maintaining stands. Alfalfa thrived wherever irrigation water and suitable land were available, and good production over a period of years was taken for granted. Insects, such as alfalfa weevil, aphids, grasshoppers, and

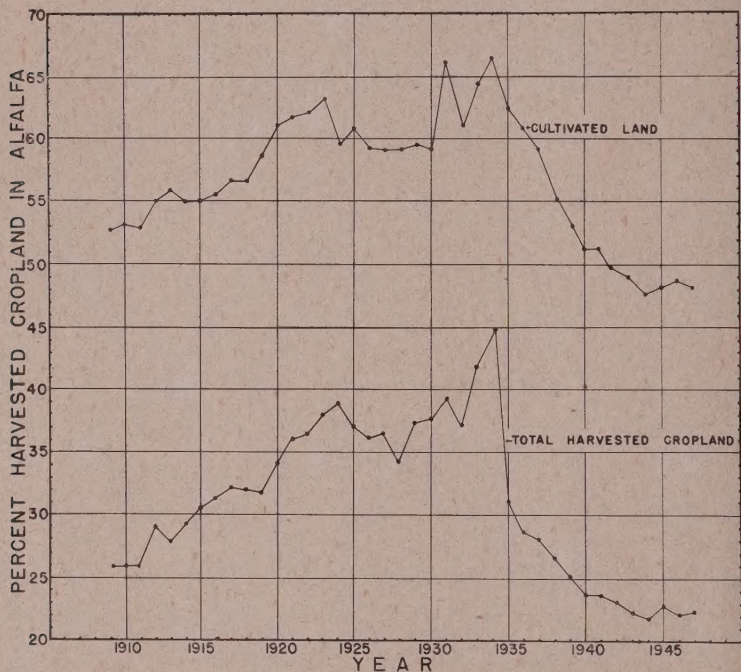


FIGURE 2. Percent Cropland in Alfalfa in Nevada, 1909 to 1947. Upper Line Shows Percent of Cultivated Land in Alfalfa and Lower Line Shows the Percent of Total Harvested Cropland in Alfalfa. Data from 1909 to 1923, inclusive, are unofficial estimates based on official U. S. Department of Agriculture estimates of all tame hay acreage. Data from 1924 to 1947 are official U. S. Department of Agriculture estimates supplied by the Bureau of Agricultural Economics.

cutworms sometimes made inroads on alfalfa production, but sporadic damage from these pests was easily detected and combated.

In the early thirties, alfalfa stands in many parts of Nevada began to thin rapidly three or four years after seeding. In 1936 it was definitely established that bacterial wilt is one of the main factors contributing to the shortened life of stands.³ In addition to bacterial wilt

³F. R. Jones, Senior Pathologist, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, visited Nevada in 1936 and definitely established the presence of the bacterial wilt disease of alfalfa.

there are other diseases and environmental conditions which tend to shorten life of stands and reduce yields, but damage from bacterial wilt is so widespread and severe that it has caused considerable loss to the alfalfa growers of the State.

It is well known from experiment station tests (4, 14, 18)⁴ and farm experience that varieties and strains of alfalfa differ in disease resistance, cold resistance, growth habit, and yield. Since 1940 the Nevada Agricultural Experiment Station in cooperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, has been conducting tests to determine which varieties are best suited to combat many of the factors which contribute to shortened life and reduced yields of alfalfa in Nevada. Also new alfalfas are being developed for areas where those grown at the present time are unsatisfactory. It is the purpose of this bulletin to bring together information obtained thus far from these investigations.

DISEASES OF ALFALFA*

Diseases are important factors in the production of alfalfa in Nevada because they reduce both the yield and quality of hay. Many diseases occur in the State, but only those of rather common occurrence will be considered.

BACTERIAL WILT

According to Jones (6) bacterial wilt is the most important disease of alfalfa in the United States. In Nevada it does more damage than all other diseases combined. It is generally distributed over the State, but usually becomes severe only in areas where sufficient irrigation water is available to provide vigorous plant growth throughout the growing season.

The first symptoms of wilt likely to attract attention are a dwarfing and yellowing of the entire plant. Stems are short, leaves are small, yellowish-green in color, often curled upward at the edges, and growth of the entire plant is slow (Figure 3). Such plants are most conspicuous after cutting when the new growth is about 8 or 10 inches tall.

When diseased plants are dug and the roots cut diagonally below the crown a brownish-yellow discoloration is seen just beneath the bark. The discolored wood is also seen when bark is stripped from the root.

The bacteria which cause this disease live in the soil. They may be spread by irrigation water, by wind-blown soil, or soil transported by farm machinery. They may also be spread from infected to healthy plants by the mower sickle or grazing animals.

The only known method of effective control lies in the use of resistant varieties. Various cultural treatments have been investigated for control of the disease, but none have been effective. Some highly resistant varieties have been introduced into the United States from other countries, but they are poor seed producers and are highly susceptible to many of the foliage diseases. Much experimental effort is being directed toward breeding new varieties which will have a high

⁴Numbers in parentheses refer to literature cited at end of bulletin.

*The scientific names of casual organisms are listed on page 14.

degree of resistance to wilt and will also be desirable in other respects. The first fruits from this research effort was the development of Ranger and Buffalo alfalfas to be discussed later in the bulletin. See p. 17.

BACTERIAL STEM BLIGHT

Bacterial stem blight occurs in the central and northern part of the State but its prevalence varies from year to year. It appears on the first crop during cool wet weather following temperatures low enough



FIGURE 3. Alfalfa Plant with Bacterial Wilt Disease (left), Healthy Plant (right). Bacterial wilt causes dwarfing and yellowing of plants. A brownish-yellow discoloration just beneath the bark of the tap root is also characteristic of the disease.

to injure the young stems. Under such environmental conditions, the disease causes a reduction in growth and yield of infected plants.

The disease is primarily on the stems, but it may also occur on the leaves. It is characterized during the early stages of development by olive-green, water-soaked lesions. Stem lesions several weeks old normally become dark brown or nearly black in color. This color is further accentuated by secondary invaders. The black-stem disease organism, page, invades practically all old lesions and causes confusion between bacterial stem blight and black stem (7).

Whenever severe damage by bacterial stem blight occurs the alfalfa should be harvested. The new growth will be free from the disease unless the shoots are injured by cold.

CROWN WART

Crown wart occurs in the western part of Nevada but it is not important. The casual fungus invades young crown buds of the plant near the surface of the soil, causing them to grow into irregularly



FIGURE 4. Crown of Alfalfa Plant Showing Large Gall Produced by the Crown Wart Fungus.

shaped white galls of various sizes (Figure 4). The galls appear in the spring, mature by early summer, and disintegrate by midsummer.

DOWNY MILDEW

Downy mildew is common on alfalfa in Nevada, but rarely causes severe reduction in yield. In stands over a year old, the disease is confined largely to the first crop on young leaves at or near the top of the plant. Infected areas are usually irregular in outline and may involve more than half of the leaf. The upper side of infected areas is pale green at first, becoming yellow or purple later. Infected leaves are curled downward, and on the underside a fine grayish fungus growth appears. In fall seeded alfalfa infection often develops on the young plants the year of seeding.

LEAF SPOT

This disease is generally present on alfalfa in Nevada but it is seldom destructive. It is most likely to cause defoliation when wind and rain lodge alfalfa and the leaves are kept damp for prolonged periods, thus providing conditions favorable for development of the disease.

Leaf spot is so named because of the circular brown or black spots

on the leaves. At the center of mature spots is a disk which is the fruiting structure of the causal fungus. The fungus lives over winter on undecayed leaves.

Varieties differ in resistance to the disease. Strains of Turkistan origin are usually more susceptible than common or variegated varieties.

YELLOW LEAF BLOTCH

Yellow leaf blotch is seldom important in Nevada. Like leaf spot it will reduce yield and quality of hay by causing defoliation under conditions favorable to disease development.

The disease is characterized by yellow elongated blotches which develop parallel to the direction of the leaf veins. On young blotches, small, orange-colored bodies develop, especially on the upper surface of the leaf. These are the fruiting bodies of the casual fungus and they soon turn brown to black with age. Lesions also develop on the stems, but less commonly than on leaves.

BLACK STEM

Black stem is rarely important in Nevada. The disease develops during cold wet conditions of early spring and late fall, but seldom develops during the summer.

The symptoms of black stem disease are dark brown or black lesions on stems and leaves. Stem lesions first appear as small black spots which enlarge rapidly and sometimes girdle the stem. The blackened areas occur most commonly near the base of affected stems. Leaf lesions first appear as small definitely limited dark brown spots but enlarge to various sizes and shapes. Severely spotted leaves turn yellow and drop from the plant.

ROOT ROT

Root rot occurs on alfalfa in Nevada only in the southern portion of the State where warm summer temperatures are favorable to its development. The causal fungus infects the roots, causes them to decay and eventually kills the plants. Damage varies from year to year but alfalfa stands are often severely injured.

The fungus first infects the bark of the root and gradually works its way into the woody cylinder until the root is rotted through. Wilting of the tops is usually the first sign of root infection and is always preceded by root decay. Infected plants often die within one or two days after the first signs of wilting.

In the field, the disease spreads in all directions from a small localized infection, killing the plants in a well-defined, somewhat circular area. At the margin of this area is a zone of dead and dying plants beyond which are apparently healthy plants (Figure 5). Surviving plants usually have tap roots which have been rotted off and are kept alive by means of one or more normal lateral roots above the decayed portion of the tap root.

Development of the disease is favored by fairly moist soil, but is affected unfavorably by either very dry or very wet soils. It is most severe at relatively high soil temperatures, optimum development occurring about 75° F.

Crop rotation is the most satisfactory method of control, although soil treatments have shown some promise in Arizona (9). Streets recommends that badly infected alfalfa fields should be plowed and planted to nonsusceptible crops for three years. Moderately or slightly infected fields may be treated with ammonium sulphate or manure and the infected areas replanted in the fall. Corn, small grains, sorghums, millet, and all grasses are immune, also asparagus, garlic, and onions. Tomatoes are moderately susceptible (10).

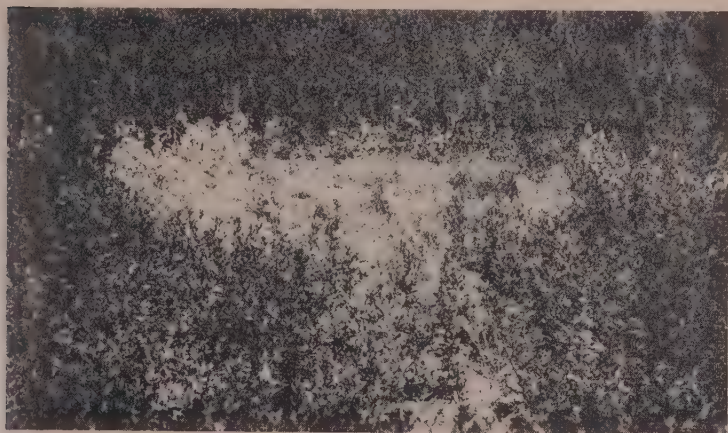


FIGURE 5. A Small Root Rot Area in One-Year-Old Field of Alfalfa near Logandale, Nevada.

STEM NEMATODE

The stem nematode causes injury in some of the important alfalfa producing regions of western Nevada. Damage varies from year to year and may result in a reduced production of hay, or a killing of the alfalfa stand in two or three years. Injury usually is most prominent in the spring and early summer, as moist spring weather apparently favors nematode infection.

Nematode injury is located principally in the crown, affecting the young buds and stem bases. Infected buds become thickened, deformed, and usually do not elongate into stems (Figure 6). Later in the season, particularly where damage has not been severe, infected plants are often dwarfed, have a reduced number of stems, some of which may be yellowed and distorted. Such plants often have stems swollen at the base and dark brown in color. Also they are brittle and easily broken off. Infected shoots sometimes have swollen areas near the tip or at nodes along the stem.

The nematodes which cause this disease may be distributed from infected areas to neighboring fields through the movement of soil and irrigation water. Also they may be transported in infected hay, or in poorly cleaned seed.

Crop rotation is helpful as a means of control (3, 11). Heavily infested fields should be plowed and seeded to other crops for at least two or three years with special care to eliminate all alfalfa and clover plants. Crops suitable for rotation include wheat, corn, barley, potatoes, and grasses.

Control by the use of resistant varieties offers good possibilities. At



FIGURE 6. Alfalfa Plant Infected with Stem Nematodes. Infected buds are swollen, deformed, and usually do not elongate. Stems infected at the base are enlarged, dark brown in color, and easily broken off.

present, Nemastan is the only variety known to be resistant to stem nematode, but this variety is a poor seed producer and does not produce satisfactory hay yields. It is being used in developing an alfalfa having desirable characteristics in addition to resistance to the stem nematode.

ROOT KNOT NEMATODE

Root knot nematode is very prevalent in Nevada. The nematodes live in the soil and attack young fine roots causing galls which appear as small scattered tubercle-like growths (Figure 7). Galls are usually sharply defined, but in some instances affected roots may be decidedly

swollen. Scattered galls may be confused with nodules formed by nitrogen-fixing bacteria. The nitrogen-fixing bacteria galls are usually rare on heavily nematode-galled plants.

The extent of damage to affected plants is not clearly understood at present, but severely affected seedling plants (Figure 7) are stunted in growth. Infection usually is more severe on sandy soils than on heavy soils, and is favored by high soil moisture.

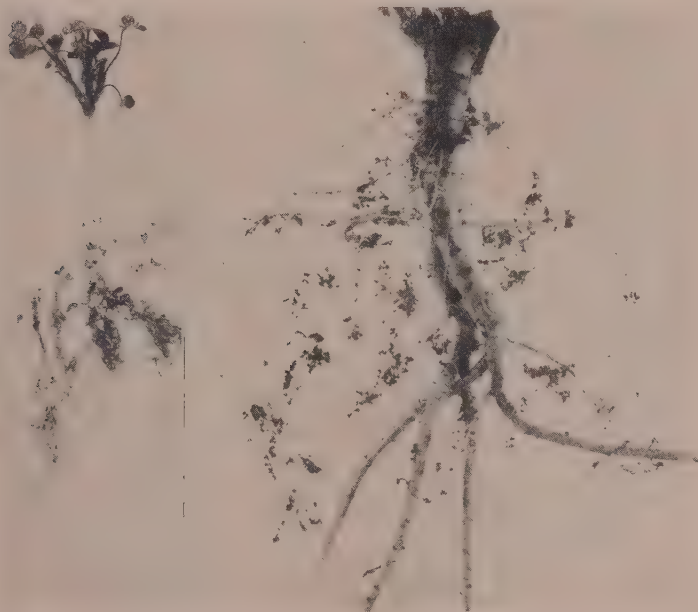


FIGURE 7. Alfalfa Plants Heavily Galled by Root Knot Nematodes. Plants from U. S. Newlands Field Station, Fallon, Nevada. Plant at the left was seeded August 26, 1941, and photographed November 1941.

WINTER INJURY

Winter injury to alfalfa in Nevada is sometimes severe. Fields have been observed where at least 95 percent of the plants were dead from this cause. Injury occurs to plants of all ages but is more likely to kill young stands seeded the previous fall or spring. When injured plants are dug in the spring the upper part of the tap root is found to be dark brown or black (Figure 8), and appears as a collar rot at the base of the crown (15, 16). The injured area usually begins in the crown and extends downward, sometimes a distance of two inches. When injury to the root is shallow, plants recover and eventually slough off the affected tissue, leaving a root surface slightly roughened where the injury occurred. Severely injured stands have always proved to be a nonwinter-hardy variety, but injured plants have been found in cold resistant varieties.

**NAMES OF DISEASES AND SCIENTIFIC NAMES OF ORGANISM WHICH
CAUSE THE DISEASES OF ALFALFA DISCUSSED**

Bacterial Wilt, *Corynebacterium insidiosum* (McC.) Bergey et al.

Bacterial Stem Blight, *Phytophthora medicaginis* (Sack.) et al.

Crown Wart, *Urophlyctis alfalfae* (Lagerh.) Magnus.

Downy Mildew, *Peronospora trifoliorum*, DeB.

Leaf Spot, *Pseudopeziza medicaginis* (Lib.) Sacc.

Yellow Leaf Blotch, *Pseudopeziza jonesii* (Fekl.) Nannf.

Black Stem, *Ascochyta imperfecta*, Pk.

Root Rot, *Phymatotrichum omnivorum*, (Shear.) Duggar.

Stem Nematode, *Ditylenchus dipsaci*, (Kuhn) Filipjev.

Root Knot Nematode, *Heterodera marioni* (Cornu) Goodey.



FIGURE 8. Winter Injury to Young Alfalfa Plants. Plant at extreme left was uninjured; other plants show different degrees of injury.

DESCRIPTION OF VARIETIES

A thorough description of alfalfa varieties in the United States is given in U. S. Department of Agriculture Farmer's Bulletin 1731. (17) Therefore, information given here will be restricted to what is considered of most importance to individuals interested in alfalfa production in Nevada.

COMMON ALFALFA

The common alfalfas are the ordinary, purple flowered, nonpubescent sort. Most of them are from seed which was introduced into California from Chile, South America, about 1850. Common alfalfa grown in Nevada is still often referred to as Chilean or Chilean type.

Through long cultivation under different climatic conditions, regional strains have evolved which differ mainly with respect to cold resistance and growth habit. Usually they are named after the State in which they are commonly grown.

The strains which have developed in the north recover more slowly after being cut than those produced in the south; they go dormant earlier in the fall and are more cold resistant. Those developed in Modoc County, California, Utah, and Kansas, and regions farther north are sufficiently winter hardy for Nevada conditions, but those from the southern regions are likely to suffer serious winter injury in the central and northern part of the State.

Some of the common varieties give high yields until damaged by bacterial wilt or stem nematodes, but none are resistant to either of these diseases.

ARGENTINE ALFALFA

According to Westover (17) "Practically all Argentine alfalfa belongs to the Common group, although several more or less distinct strains have developed as a result of having been grown under widely varying conditions of climate and latitude. Most of the seed brought to the United States is produced south of Buenos Aires where climatic conditions are much less severe than those at a similar latitude in this country and, therefore, are not conducive to the development of a hardy strain. The tests thus far conducted in the United States indicate that some Argentine strains are less hardy and that the hardiest are no harder than Kansas Common. For this reason Argentine alfalfa cannot be sown with safety any farther north than Kansas alfalfa is known to succeed."

Conflicting reports are received from farmers of Nevada regarding success with Argentine alfalfa. Some report good success and others report losing stands in two or three years after seeding. Strain differences undoubtedly account for some of these results. Since Kansas Common has so far proved hardy enough for winter conditions at Reno it is reasonable to expect that some strains of Argentine will also be hardy enough to stand winter conditions in this general area, whereas, the nonhardy strains will not.

In a single-row nursery of introductions which was seeded on the U. S. Newlands Field Station at Fallon, Nevada, in 1941, the row of Argentine (F. P. I. 142,062) was 100 percent killed during the winter of 1941-1942. That same winter, California Common and Arizona Common growing in field plots were also injured.

Tests elsewhere (4, 14) show that Argentine alfalfa is susceptible to bacterial wilt. This character and the uncertainty of its ability to withstand winter conditions in central and northern Nevada make it advisable not to seed Argentine alfalfa in those areas.

COSSACK

Cossack alfalfa is a cold resistant variety introduced into the United States from Russia in 1907 by the United States Department of Agriculture. It is one of the highest yielding varieties tested in Nevada when free of bacterial wilt and stem nematode.

LADAK

Ladak was imported to the United States from northern India by the United States Department of Agriculture in 1910. It produces a very high yield in the first cutting, which makes it well adapted to areas where there is only sufficient water for one or two crops a year. It is slow to recover after being cut, and goes dormant early in the fall.

In tests in Nevada it has yielded 91 percent as much as Ranger. The variety is susceptible to the stem nematode, but is moderately resistant to bacterial wilt. Under irrigation where wilt damage is severe it will maintain a stand one to two years longer than Grimm.

Foliage of Ladak has proved to be more resistant to freezing temperatures in the spring than the foliage of any other variety tested in Nevada.

GRIMM

Grimm alfalfa was imported to Minnesota from Germany by Wendelin Grimm in 1857. In its early history this alfalfa attracted considerable attention because of its high degree of cold resistance.

In Nevada tests it has been a high-forage yielder unless injured by bacterial wilt, but due to its high susceptibility to this disease it will not maintain full production longer than two or three years where damage from bacterial wilt is severe. It is also susceptible to the stem nematode.

BALTIC

According to Westover (17) "There is no authentic record of the introduction of Baltic alfalfa into this country, although there is no doubt that the original stock came from Europe. The name Baltic was first applied to it in 1906 for the reason that it had been grown for about ten years near Baltic, South Dakota."

Baltic is sufficiently winter-hardy for Nevada conditions, but it has not been grown commercially in the State. In test plots it has yielded well until damaged by bacterial wilt or stem nematodes.

HARDIGAN

Hardigan is a selection from Baltic made at the Michigan State College of Agriculture. The selection was made on the basis of its ability to produce large yields of seed and its adaptation to conditions of northeastern United States.

It has not been grown commercially in Nevada, but in test plots it has yielded less than Baltic. It is susceptible to bacterial wilt and the stem nematode.

HARDISTAN

Hardistan is a strain of Turkistan which gained prominence in Nebraska and was named Hardistan by the Nebraska Agricultural Experiment Station. It is cold resistant and highly resistant to bacterial wilt, but is very susceptible to leaf spot, yellow-leaf blotch, and stem nematode.

In test plots on wilt-infested soil it has yielded 93 percent as much as Ranger over a five-year period and maintained a full stand. It has not been grown commercially in Nevada to any extent, mostly because seed has not been available.

ORESTAN

Orestan is a strain of Turkistan which was imported by the United States Department of Agriculture. In tests by the Oregon Agricultural Experiment Station this introduction did very well and was named Orestan. It is cold resistant, highly resistant to bacterial wilt, but is susceptible to leaf spot, yellow-leaf blotch, and the stem nematode.

In all Nevada tests it has yielded 96 percent as much as Ranger. Mostly because of a scarcity of seed this variety has not been grown extensively in Nevada.

RANGER

As described by Tysdal (12) Ranger is a synthetic variety produced through the cooperative efforts of the Nebraska Agricultural Experiment Station and the Division of Forage Crops and Diseases, United States Department of Agriculture. It may be called a multiple strain variety synthesized from five selections originating from the varieties Cossack, Turkistan, and Ladak.

Ranger alfalfa exhibits considerable variability both in habit of growth and flower color. It is distinctly variegated in flower color, but only occasionally, if at all, are yellow flowered plants observed. The plants differ in habit of growth from decumbent to upright. The variety has a greater rapidity of recovery after cutting than Ladak or Cossack, being about the same as Grimm in this respect.

The outstanding characteristic of Ranger is its high degree of resistance to bacterial wilt. This character enables it to maintain stands much longer than wilt-susceptible varieties where this disease is serious on alfalfa. It is more susceptible to the leaf spot diseases than Cossack or Grimm, but not as susceptible as Hardistan. It is susceptible to the stem nematode.

It is about equal to Grimm in cold resistance. For all Nevada tests it has been the highest-yielding variety.

BUFFALO

Buffalo alfalfa was produced through the cooperative efforts of the Kansas Agricultural Experiment Station and the Division of Forage Crops and Diseases, United States Department of Agriculture (12). It is a selection from an old strain of Kansas Common known to have been grown in Kansas before 1907.

Like all common alfalfa, Buffalo has a bluish-purple flower ranging from a light blue to a reddish purple. When grown by itself it cannot be distinguished from ordinary Kansas Common.

The outstanding feature of Buffalo is its high degree of resistance to bacterial wilt. This character enables it to maintain stands and produce high yields longer than wilt-susceptible varieties.

In Nevada tests, Buffalo has proved to be one of the high-yielding varieties. In tests so far conducted it has produced 95 percent as much as Ranger. But like Ranger it is susceptible to the stem nematode.

NEMASTAN

Nemastan is a strain of Turkistan which was imported by the United States Department of Agriculture. This strain was found to be resistant to the stem nematode in Utah in 1933 and 1934 (2). It was tested

in Nevada in 1941 and 1942 where it attracted attention because of its outstanding resistance to this nematode. In 1943 (13) the United States Department of Agriculture, cooperating with the experiment stations of Nevada and Utah named it Nemastan and increased it for use in nematode-infested areas of these States.

Nemastan is purple-flowered and resembles Common alfalfa. It is upright in growth habit and recovers rapidly after being cut. In tests so far it has been sufficiently winter hardy for Nevada conditions.

Where the stem nematode is not a factor in alfalfa production, Nemastan produces about 83 percent as much as Ranger and therefore is recommended only where the stem nematode is a factor in alfalfa production.

This variety is also resistant to bacterial wilt but not as resistant as some of the other Turkistan alfalfas, such as Hardistan or Orestan.

COMPARATIVE VARIETY TESTS

Since 1940 field tests have been conducted to determine what variety or varieties of alfalfa are best adapted to Nevada conditions. Seedlings were made in Churchill, Douglas, Elko, Pershing, Washoe, and White Pine Counties. Hay yields were determined on plots near Reno, and observations only were made on plots located too far from Reno to make harvesting of plots feasible. All harvested plots were cut three times each season. Twenty varieties were used in the tests. All plots were located where an ample supply of irrigation water was assured and on land reasonably well suited for alfalfa hay production.

Because of warmer climate and the presence of the root rot organism in southern Nevada, conditions for growing alfalfa are quite different than in other parts of the State.

Variety test plots were established in 1948 in Clark County, but results are not far enough advanced to make definite variety recommendations possible for that area.

VARIETY TESTS IN CHURCHILL COUNTY

Ten varieties and nine strains were seeded on the U. S. Newlands Field Station, Fallon, Nevada, in August 1942.* Each variety was replicated four times in 5-row plots 5.5 feet wide and 25 feet long.

Yields were determined from 1943 to 1947. Nearly all varieties produced high yields the first and second years, but production began to decline in most varieties in the third-crop year. In the fifth year, some varieties such as Baltic and Arizona Chilean yielded only about half as much as they did in the second year, whereas, Ranger and Buffalo produced 95 percent and 90 percent, respectively, of their second-year production. For the five-year period, Ranger averaged one ton per acre per year more hay than the best wilt-susceptible variety, Grimm. Buffalo yielded 95 percent as much as Ranger for the five years (Table 1).

*Cooperative investigations with F. M. Willhite, Associate Agronomist, Division of Soil Management and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

TABLE 1

Comparative yields and estimated percent stand of ten varieties and nine strains of alfalfa grown in field plots on the U. S. Newlands Field Station, Fallon, Nevada. Plots seeded August 21, 1942.

Progeny	TONS PER ACRE (12% MOISTURE)						PERCENT STAND	
	1943	1944	1945	1946	1947	Average	1942	1947
Ranger	6.24	8.66	8.68	7.87	8.21	7.93	100	100
A172 Nebraska	5.82	8.64	8.73	8.01	8.09	7.86	100	100
A176 Nebraska	5.71	8.59	8.74	7.88	8.07	7.80	100	100
A114 Nebraska	6.25	8.72	8.43	7.61	7.74	7.75	100	100
A115 Nebraska	6.38	8.62	8.67	7.45	7.50	7.72	100	100
Buffalo	5.64	8.56	8.48	7.39	7.71	7.56	100	100
A195 Nebraska	5.57	8.59	8.39	7.46	7.79	7.56	100	100
A147 Kansas	5.94	8.53	8.40	7.38	7.56	7.56	96	94
Hardistan	5.71	8.44	7.82	7.07	7.43	7.29	100	100
A8 Kansas	6.25	8.86	7.70	6.55	7.00	7.27	100	97
Grimm	6.46	8.71	7.48	6.19	6.01	6.97	100	88
Orestan	5.44	7.86	7.42	6.71	7.20	6.93	100	100
A179 Utah	6.51	8.75	7.20	6.08	5.75	6.86	100	85
Kansas Common ..	6.79	8.88	7.33	5.55	5.40	6.79	100	82
Ladak	6.17	7.54	7.22	6.34	5.90	6.63	100	95
A169 Nebraska	4.67	7.16	7.13	6.59	6.89	6.52	90	90
Arizona Chilean...	6.41	8.73	6.25	4.87	4.45	6.14	100	63
Baltic	6.23	8.27	5.96	4.33	4.09	5.78	100	57
Viking	5.46	7.30	5.87	4.88	4.72	5.65	100	92
Significant difference ¹ (19:1) ..	.78	.66	.70	.59	.46	.44		

¹This means, for example, that in the fifth year the odds are 19 to 1 or greater that Ranger would yield more than any other strain or variety excepting A172 and A176 Nebraska, if the test were repeated.

Thinning of stands, due to bacterial wilt, was the major factor causing reduction in yield after the second year. All varieties had full stands the first and second years and the wilt-resistant varieties, Ranger, Buffalo, Orestan, and Hardistan all had full stands at the end of five years. Stands of wilt susceptible varieties, Baltic and Arizona Common, were reduced 43 percent and 37 percent, respectively, five years after seeding (Table 1). No disease other than bacterial wilt appreciably influenced longevity of stands or hay production during the five-year period nor was there any apparent winter injury to any variety.

VARIETY TESTS IN DOUGLAS COUNTY

In Douglas County, variety test plots were established near Minden on August 26, 1940. Sixteen varieties were replicated four times in plots twenty feet long and approximately four feet wide. The plots were located in an area where bacterial wilt does serious damage to alfalfa.

Hay yields were taken from 1941 to 1945. Nearly all the varieties produced high yields the second year of production, but yields of wilt-susceptible varieties declined rapidly in later years. In the second year of production the highest yielding wilt-susceptible varieties, Cossack, Baltic, Grimm, and Kansas Common, yielded as much as the two best yielding wilt-resistant varieties, Ranger and Orestan. In the fifth year these wilt-susceptible varieties yielded only about one-half as much as Ranger or Orestan. Furthermore, Ranger and Orestan produced about

as much the fifth year as they did the second year, whereas, the above-mentioned wilt-susceptible varieties produced about half as much the fifth year as in the second year (Table 2).

TABLE 2

Comparative yields and estimated percent stands of 16 varieties of alfalfa grown in field plots at Minden, Nevada. Plots seeded August 26, 1940.

Variety	TONS PER ACRE (AIR DRY)						PERCENT STAND	
	1941	1942	1943	1944	1945	Average	1941	1947
Orestan	6.48	6.07	5.41	5.32	5.05	5.66	100	93
Ranger	5.61	6.26	5.63	5.18	5.36	5.61	100	94
Hardistan	6.27	5.96	4.87	4.55	4.89	5.31	100	88
Dakota Common ..	6.39	6.76	5.36	4.25	3.74	5.30	100	61
Cossack	6.55	6.02	4.69	3.37	3.34	4.79	100	17
Kansas Common....	6.10	5.81	5.04	3.77	3.17	4.78	100	40
Ladak	5.39	5.97	5.13	3.46	3.94	4.78	100	70
Ladak	5.40	6.01	5.09	3.43	3.75	4.75	100	70
Baltic	6.87	6.51	4.41	2.22	2.56	4.51	100	9
Utah Common	5.48	5.67	4.76	3.44	3.01	4.47	100	21
Calif. Common								
(South. grown) ..	6.39	5.13	4.73	3.17	2.82	4.45	100	8
Grimm	6.12	6.35	4.11	1.86	2.28	4.14	100	12
Calif. Common.....	5.53	5.07	4.41	2.51	2.12	3.93	100	8
Hardigan	6.09	5.83	3.92	1.72	1.87	3.89	100	20
Ariz. Common	5.48	4.96	3.89	2.05	1.90	3.66	100	9
Nevada Common								
(Minden)	4.60	4.96	3.97	2.07	2.06	3.53	100	6
Calif. Common								
(Modoc County) ..	4.50	4.99	4.02	2.14	1.78	3.49	100	6
Significant difference (19:1).....	.59	.61	.70	.50	.55	.46		

Thinning of stands due to bacterial wilt was the major factor which caused reduction in yields after the second year. All varieties had full stands for the first two years, but in the third year plants of the wilt-susceptible varieties began to die of bacterial wilt. Four years after seeding, stands of the wilt-susceptible varieties were drastically thinned (Figure 9), and seven years after seeding many were killed, approximately 90 percent, whereas, Ranger, Orestan, and Hardistan had 94 percent, 93 percent, and 88 percent stands, respectively.

Winter conditions of 1941-1942 caused injury to California Common and Arizona Common alfalfas. Spring growth was slow to start and the plants lacked the healthy dark-green appearance of young shoots or uninjured varieties (Figure 10). When injured plants were dug and examined the crown and upper part of the tap roots showed characteristic winter injury as described on page 13. In a nearby hay field which was seeded half to California Common and half to Grimm, the California Common suffered winter injury, was slow to commence spring growth, and many weeds established themselves among the alfalfa plants. The Grimm alfalfa was uninjured, grew vigorously in the spring, and very few weeds became established.

During the period of May 12 to May 19, 1943, freezing temperatures injured top growth of alfalfa in the vicinity of Minden, Nevada. Temperatures as low as 18° F. were recorded. Alfalfa growth was about ten inches high and contrasting differences were noted in the degree of injury to the different varieties. Ladak was the least injured of any



FIGURE 9. 1, Ranger; 2, Grimm; 3, Orestan. Where bacterial wilt damages alfalfa wilt-resistant varieties, Ranger and Orestan, maintain stands longer than wilt-susceptible varieties such as Grimm. Plots seeded on Dangberg farm, Minden, Nevada, August 26, 1940. Photographed September 14, 1944.



FIGURE 10. Winter Injured California Common Alfalfa in Field Plots on Dangberg Farm, Minden, Nevada. Left, Cossack; center, California Common; right, Hardistan. The winter injured variety is slow to commence spring growth, and the foliage lacks the healthy, dark-green appearance of uninjured plants. Photographed April 26, 1942.

variety, only the tops of a few stems were frozen. The foliage of Arizona Common, California Common, and Orestan was severely damaged. Injury to Ranger, Baltic, Cossack, Kansas Common, Hardistan, and



FIGURE 11. Top Growth of Alfalfa Injured by Freezing Temperatures.
Left, Grimm; right, Orestan.

Dakota Common was moderate, being comparable to damage to Grimm, as shown in Figure 11.

VARIETY TESTS IN PERSHING COUNTY

The variety test plots in Pershing County were seeded near Lovelock, May 11, 1943. Twelve varieties were replicated five times in plots four feet wide and 25 feet long. Yields were determined the following three seasons. In this area bacterial wilt has not been observed in fields fewer than eight years old and the disease at present is not a serious factor in hay production. Thus, the three-year test was considered sufficient to give the relative yielding capacity of the different varieties in that region.

All varieties except California Common from Modoc County produced high yields for the three-year period. The lower yields in all varieties in the third year was due to a less favorable growing season. All varieties retained a full stand at the end of the three-year test.

The results given in Table 3 clearly show that for this area where bacterial wilt is not a factor in alfalfa production varieties such as Cossack, Baltic, or Ladak yield about the same as Ranger.

VARIETY TESTS IN WASHOE COUNTY

In a few areas in western Nevada including parts of Washoe County bacterial wilt and stem nematodes both injure alfalfa. Bacterial wilt is the more widespread and is more constant in doing damage, but stem nematode causes severe injury when environmental conditions favor its development. Nemastan is the only variety known to be resistant to the stem nematode and it is also quite resistant to bacterial

wilt. In forage production it is inferior to high-yielding varieties. This variety and seven others were replicated three times in plots four feet wide and 30 feet long on the Nevada Agricultural Experiment Station Farm at Reno, Nevada. The plots were seeded August 20, 1943, and yields determined the three following seasons. Results (Table 4) shows that Nemastan produced about one ton per acre less hay than Ranger or other high-yielding varieties. Neither bacterial wilt nor any other environmental factor thinned the stand of any variety during the three years.

TABLE 3

Comparative yields of 12 varieties of alfalfa grown in field plots near Lovelock, Nevada. Plots seeded May 11, 1943.

Variety	—TONS PER ACRE (12% MOISTURE)—			
	1944	1945	1946	Average
Ladak.....	8.08	8.62	7.02	7.91
Ranger.....	7.48	8.50	7.39	7.79
Baltic.....	7.71	8.58	6.91	7.73
Kansas Common.....	7.17	8.52	7.35	7.68
Cossack.....	7.42	8.19	6.73	7.44
Dakota Common.....	7.25	8.04	6.99	7.43
Grimm.....	7.44	8.19	6.62	7.42
California Common.....	7.19	7.95	7.00	7.38
Arizona Common.....	6.92	7.68	7.18	7.26
Utah Common.....	6.76	7.98	6.74	7.16
Orestan.....	7.13	7.91	6.36	7.13
California Common (Modoc County).....	6.35	7.35	6.18	6.39
Significant difference (19:1).....	.34	.49	.44	.26

TABLE 4

Comparative yields per acre of hay (12 percent moisture) of eight varieties of alfalfa grown in field plots at Reno, Nevada. Plots seeded August 26, 1943.

Variety	—TONS PER ACRE (12% MOISTURE)—			
	1944	1945	1946	Average
Ranger.....	5.40	7.33	8.38	7.04
Orestan.....	5.21	7.47	8.18	6.95
Dakota Common.....	5.36	7.39	7.17	6.64
Ladak.....	6.07	6.87	6.58	6.51
Cossack.....	5.55	7.08	6.74	6.44
Baltic.....	5.57	6.97	6.25	6.26
Nemastan.....	4.20	6.30	7.07	5.84
California Common (Modoc County).....	5.08	5.86	6.27	5.74

Since none of the high-yielding varieties are resistant to both bacterial wilt and stem nematodes it is desirable to develop a high-yielding variety which is highly resistant to both diseases. Nemastan is resistant to the stem nematode and selections from that variety are being used as a source of stem nematode resistance in developing an alfalfa which will produce a high yield and be resistant to the stem nematode and bacterial wilt.

Polycross progenies (open-pollinated seed from selected plants grown in isolation with a large number of other selected plants) from Nemastan plants have thus far produced high yields and are resistant to bacterial wilt and stem nematode. Nine of these progenies and the varieties Ranger, Buffalo, and a local strain were seeded in duplicate plots three feet wide and thirty feet long, August 21, 1945. Insufficient seed of the polycross progenies prevented a more extensive seeding at that time.

TABLE 5

Comparative yields and estimated percent stand of nine polycross progenies of selections from Nemastan, two varieties, and one local strain grown in field plots at Reno, Nevada. Plots seeded August 15, 1945.

Progeny	—TONS PER ACRE (12% MOISTURE)—			—PERCENT STAND—	
	1946	1947	Average	1945	1947
C-89.....	6.13	8.85	7.49	95	95
N-48.....	5.86	8.40	7.13	100	100
N-39.....	5.10	8.26	6.68	100	100
C-84.....	4.69	8.24	6.47	100	100
C-86.....	5.10	7.77	6.44	90	80
N-51.....	4.80	7.56	6.19	100	100
N-35.....	4.62	7.83	6.23	100	90
N-30.....	4.71	7.39	6.05	100	100
C-83.....	4.06	6.77	5.42	92	90
Ranger.....	4.36	6.07	5.22	95	50
Local Strain (Nevada).....	4.73	5.21	4.97	100	50
Buffalo.....	4.86	4.80	4.83	85	50

The plots were located where heavy infection from stem nematodes and bacterial wilt was very likely to occur. Hay yields (Table 5) determined in 1946 and 1947 show that progenies from all the selections yielded higher than Ranger, Buffalo, or the local strain, and the highest yielding progenies produced as much as any of these varieties have produced in Nevada tests when they were not injured by stem nematodes. The low yields of Ranger, Buffalo and the local strain in this test were due to damage by the stem nematode (Figure 12). At the end of two years these nematode susceptible varieties have approximately 50 percent stands, whereas, nematode resistant polycross progenies have full stands.

SUMMARY OF YIELDS

Yields of all tests are summarized in Table 6. Relative yields based on Ranger as 100 are given in the last column. Ranger was seeded in all tests and was the highest producing variety. Ladak yielded more than Ranger in the three-year test in Pershing County, but for all tests it produced 91 percent as much as Ranger. Buffalo was included in only one test and produced 95 percent as much as Ranger. It maintained a full stand during the five-year test. Dakota Common produced 95 percent as much as Ranger and in the five-year test in Douglas County where bacterial wilt is prevalent it maintained a stand longer than other Common varieties. The southern Commons have proved to be generally inferior to other alfalfas. Orestan and Hardistan yielded 94 and 93 percent, respectively, of Ranger. These two varieties have also yielded less than Ranger in both forage and seed production in other parts of the country and therefore have been practically eliminated as commercial varieties. On the other hand Ranger is being rapidly increased and seed is now available on the market.

SUMMARY

Alfalfa is one of the most important crops in Nevada. Approximately 22 percent of the harvested cropland and 48 percent of the cultivated land in the State are devoted to alfalfa production. Its most important role is that of furnishing feed for livestock.

In the early days of alfalfa growing in Nevada high production of good quality hay was maintained for fifteen to twenty years or longer,



FIGURE 12. The Stem Nematode Checks Spring Growth of Alfalfa and Reduces Yields. Heavily Infected Plants are Often Killed. Above—Plots showing no spring growth, due to stem nematode damage, are Ranger, Buffalo, and a local strain. Other plots are stem nematode resistant polycross progenies of selections from Nemastan. Photographed March 18, 1947. Below—Same as above. Photographed April 7, 1947. Plots seeded August 15, 1945.

but in the early thirties stands in many areas began to thin rapidly three or four years after seeding.

TABLE 6

Summary of yields in tons per acre of alfalfa grown in field plots in Nevada.

Variety	Churchill County, 5 years 1943-1947	Douglas County, 5 years 1941-1945	Pershing County, 3 years 1944-1946	Washoe County, 3 years 1944-1946	Percent of Ranger
Ranger.....	7.93	5.61	7.79	7.04	100
Buffalo.....	7.56	.....	.....	.....	95
Dakota Common.....	.....	5.30	7.43	6.64	95
Orestan.....	6.93	5.66	7.13	6.95	94
Hardistan.....	7.29	5.31	.....	.....	93
Cossack.....	.....	4.79	7.44	6.44	93
Ladak.....	6.63	4.78	7.91	6.51	91
Kansas Common.....	6.79	4.78	7.68	.....	90
Grimm.....	6.97	4.14	7.42	.....	87
Utah Common.....	.....	4.47	7.16	.....	87
California Common.....	.....	3.93	7.38	.....	86
Arizona Chilean.....	6.14	.....	.....	.....	86
Baltic.....	5.78	4.51	7.73	6.26	85
Nemastan.....	.....	.....	.....	5.84	83
Arizona Common.....	.....	3.66	7.26	.....	81
California Common (Southern grown).....	.....	4.45	.....	.....	79
California Common (Modoc County).....	.....	3.49	6.39	5.74	76
Viking.....	5.65	.....	.....	.....	71
Hardigan.....	.....	3.89	.....	.....	69
Nevada Common (Minden).....	.....	3.53	.....	.....	63

Several disease organisms affect alfalfa in Nevada, by reducing production and shortening the life of stands. Bacterial wilt is the most widespread and destructive of all the diseases. It occurs in practically all the alfalfa-growing areas of central and northern Nevada and causes severe damage in most areas where sufficient water is available to provide good plant growth throughout the season. Under liberal use of irrigation water, which is favorable to development of bacterial wilt, stands of susceptible varieties often live only three or four years after seeding. The only known means of control is by the use of resistant varieties.

Bacterial stem blight develops in the central and northern part of the State when cool wet weather occurs. Heavily infected fields should be harvested early. The subsequent new growth is usually free from the disease. The stem nematode is present in a few areas of western Nevada and when conditions are favorable for development this eel-worm will kill a stand of nematode susceptible plants in two or three years.

Root rot does considerable damage to alfalfa in the southern portion of the State. Severely damaged stands should be plowed and the land seeded to a resistant crop such as a small grain which is resistant to the causal fungus.

Other diseases which occur on alfalfa in Nevada but seldom do appreciable damage are: crown wart, downy mildew, black stem, leaf spot, and yellow leaf blotch. Root knot nematodes occur on alfalfa roots, but the extent of damage to the plant is not clearly understood.

Alfalfa variety test plots have been grown in several counties in the State to determine which varieties are best adapted to Nevada conditions. Results obtained to date warrant the following conclusions: Where bacterial wilt is a serious factor in alfalfa hay production, and the stem nematode is absent the wilt resistant varieties, Ranger or Buffalo should be used. So far Ranger has given a little higher hay production than Buffalo, but both have proved highly resistant to bacterial wilt and have maintained full stands in field plots for eight and five years, respectively. This is the maximum number of years the respective varieties have been under observation and it is not known at present how much longer they will maintain good stands. Orestan and Hardistan are good wilt-resistant varieties, but they have not yielded as well as Ranger or Buffalo, and seed is not available. For areas where neither bacterial wilt nor stem nematodes are factors in hay production, Baltic, Cossack, Grimm, and in some areas Ladak, are equally as good as Ranger or Buffalo. Ladak is recommended for areas where only one cutting during the season is obtained, because of its relatively high yield in the first crop. Of the varieties tested, the top growth of Ladak is the most resistant to freezing temperatures which occur in the spring. In areas where the stem nematode seriously damages alfalfa, Nemastan should be seeded. This variety is highly resistant to stem nematode and is quite resistant to bacterial wilt. Selections from Nemastan are being developed which combine resistance to bacterial wilt and stem nematode with high forage and seed yield.

LITERATURE CITED

1. ALLEN, M. W.
1942. Report on Nematode Investigations in Western Nevada During the Season of 1942. (Unpublished data.)
2. EVANS, R. J.
1948. Letter Correspondence. April 23.
3. GODFREY, G. H.
1923. The Eelworm Disease: A Menace to Alfalfa in America. U. S. D. A. Cir. 297.
4. GRANDFIELD, C. O., AND THROCKMORTON, R. I.
1945. Alfalfa in Kansas. Kan. Agr. Exp. Sta. Bul. 328.
5. JONES, F. R.
1918. Yellow Leaf Blotch of Alfalfa Caused by the Fungus *Pyrenopeziza medicaginis*. Jour. Agr. Res. 13: 302-329.
6. JONES, F. R.
1940. Bacterial Wilt of Alfalfa and Its Control. U. S. D. A. Cir. 573.
7. RADER, WILLIAM E.
1942. Stem Blight of Alfalfa in Utah. A Complex of Two Distinct Diseases. Masters Degree Thesis, Utah State Agricultural College.
8. ROGERS, C. H.
1938. The Relation of Moisture and Temperature to Growth of the Cotton Root Rot Fungus. Jour. Agr. Res. 58: 701-709.
9. STREETS, R. B.
1938. Control of *Phymatotrichum* (Cotton or Texas) Root Rot in Arizona. Ariz. Ext. Cir. 103.
10. TAUBENHAUS, J. J. AND EZEKIEL, WALTER N.
1936. A Rating of Plants with Reference to Their Relative Resistance or Susceptibility to *Phymatotrichum* Root Rot. Texas Agr. Exp. Sta. Bul. 527.

11. THORNE, GERALD.
1932. Alfalfa-Stem Nematode Causing Severe Damage in Some Western Areas. U. S. D. A. Yearbook, pp. 99-101.
12. TYSDAL, H. M.
1942. Report of the Uniform Advanced Alfalfa Nurseries.
13. TYSDAL, H. M.
1943. Report of the Uniform Advanced Alfalfa Nurseries.
14. TYSDAL, H. M. AND KIESSELBACH, T. A.
1941. Alfalfa in Nebraska. Nebr. Agr. Exp. Sta. Bul. 331.
15. WEIMER, J. L.
1927. Observations on Some Alfalfa Root Troubles. U. S. D. A. Cir. 425.
16. WEIMER, J. L.
1930. Alfalfa Root Injuries Resulting From Freezing. Jour. Agr. Res. 40: 121-143.
17. WESTOVER, H. L.
1934. Alfalfa Varieties in the United States. Farmer's Bulletin 1731. Rev. 1945.
18. WILLARD, C. J., THATCHER, L. E., AND CUTLER, J. S.
1934. Alfalfa in Ohio. Ohio Agr. Exp. Sta. Bul. 540.





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